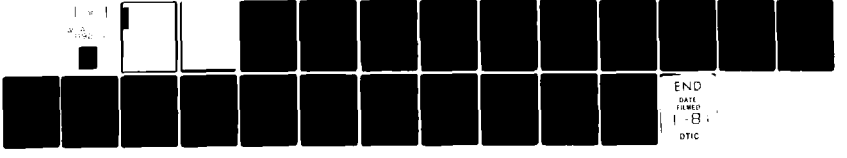
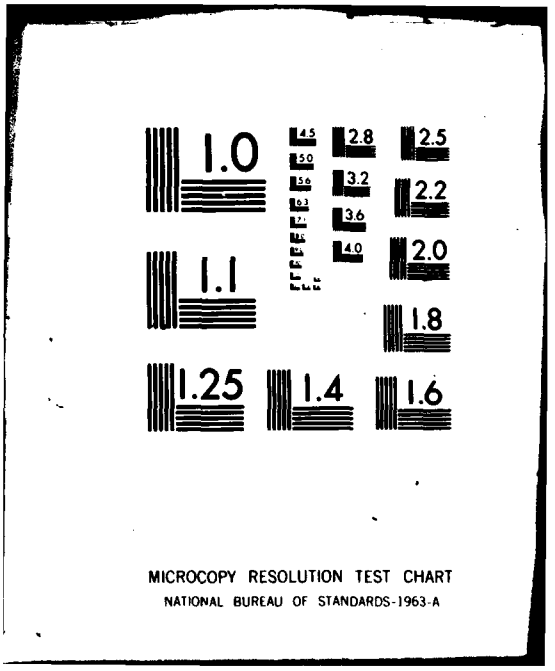
AD-A092 701 MASSACHUSETTS INST OF TECH LEXINGTON LINCOLN LAB F/G 20/12
ADVANCED ELECTRONIC TECHNOLOGY.(U)
AUG 80 A J MCLAUGHLIN, A L MCWHORTER F19628-80-C-0002
ESD-TR-80-95
UNCLASSIFIED NL



END
DATE FILMED
1-81
DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

ADVANCED ELECTRONIC TECHNOLOGY

QUARTERLY TECHNICAL SUMMARY REPORT
TO THE
AIR FORCE SYSTEMS COMMAND

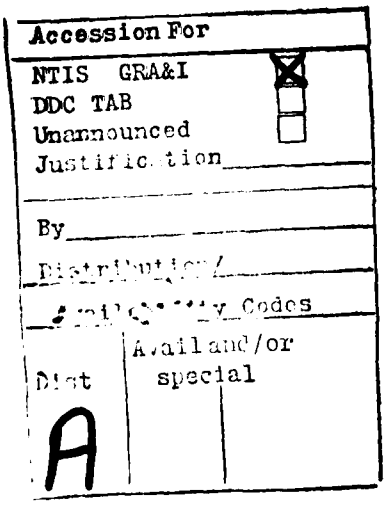
1 MAY – 31 JULY 1980

ISSUED 25 SEPTEMBER 1980

LEXINGTON MASSACHUSETTS

INTRODUCTION

This Quarterly Technical Summary covers the period 1 May through 31 July 1980. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.



CONTENTS

DATA SYSTEMS
DIVISION 2

INTRODUCTION

This section of the report reviews progress during the period 1 May through 31 July 1980 on Data Systems. Separate reports describing other work of Division 2 are issued for the following programs:

Seismic Discrimination	DARPA/NMRO
Distributed Sensor Networks	DARPA/IPTO
Network Speech Systems Technology	OSD-DCA
Digital Voice Processing	AF/ESD
JTIDS Speech Processing	AF/ESD
Packet Speech Systems Technology	DARPA/IPTO
Radar Signal Processing Technology	ARMY/BMDATC
Restructurable VLSI Technology	DARPA/IPTO
Multi-Dimensional Signal Processing	AF/RADC

A. J. McLaughlin
Head, Division 2

T. Bially
Associate Head

DIGITAL INTEGRATED CIRCUITS
GROUP 23

I. INTRODUCTION

Connecting vias for Restructurable VLSI have been formed using both a commercial laser zapper and a CW argon laser. Mask sets for a CMOS gate array and scaled NMOS devices have been laid out. Photosensitive polyimide has been used successfully as a resist, and 100-Å oxynitride films have been fabricated by nitridation of thermally grown silicon dioxide.

II. MNOS MEMORY

A. 64-kbit Memory Arrays

Processing of 64K memory array wafers was accelerated in order to produce a collection of good chips for full functional evaluation with the new computer-controlled MNOS memory exerciser. Problems which were identified and solved in the memory chip process related to anomalously high epi doping, poor nitride storage, and poor contact cut etching. The primary yield detractor now on 64K chips is believed to be photolithographic defects. The use of our new DSW wafer stepper should substantially improve this situation when it is finally operational.

Avalanche breakdown in deep depletion in the Si substrate of MNOS memory capacitors is used as a threshold to provide a write inhibit on half-selected bits in crosspoint capacitor arrays. Experimental measurements on these arrays on SOS using Ne-damaged Si isolation between Si digit lines indicates that the avalanche threshold does inhibit writing on half-selected bits for write times of 10 μsec or less. However, with longer write times thermal generation of minority carriers at the damaged Si isolation sidewall reduces the inhibit voltage across the deeply depleted MNOS capacitor substrate, which results in an increased write disturb on half-selected tubs.

A viable process was developed for using positive photoresist as a neon implant mask in the damaged Si isolation process used in the memory. This involved lowering the resist postbake temperature and using mechanical wafer heatsinking during the Ne implant step to prevent resist flow. Using a positive resist mask simplifies and improves the reliability of the damaged Si isolation process.

B. On-Chip MNOS Memory Sense Amplifier

An on-chip charge-transfer sense amplifier has been designed for the MNOS capacitor memory. It is large (14 transistors with total gate width of about 750 μm) and complicated (nine clocks, several with multiple levels and controlled transition times). Simulations with the SPICE2 circuit-analysis program show that, for bit capacitance on the order of 30 fF and bitline capacitance up to 4 pF, a memory array will operate with a 5-μsec cycle time. The ratio of signal-to-random-noise is on the order of 60 dB.

C. Array Testing

A margin checking box has been added to the sense amplifier output comparator which allows variation and digital display of the sense threshold. Programs are being written to display bad-bit maps and histograms for various worst-case storage patterns including the effect of read disturb and long-time storage decay.

III. RESTRUCTURABLE VLSI

A. Bulk CMOS Test Chip

Design of masks for a bulk CMOS test chip which is oxide isolated with self-aligned polysilicon gates and single-level metal has been completed. Its fabrication requires 9 masks.

The test chip includes a gate-array with 240 CMOS transistor pairs which are grouped into 6 columns of 20 cells, each cell being two CMOS transistor pairs. Each cell can be configured into two inverters, a 2-input NAND gate, a 2-input NOR gate, or a transfer gate. Flip-flops, latches, exclusive-OR gates, AND-NOR gates, OR-NAND gates, larger NAND gates or NOR gates, and dynamic storage elements can be obtained by interconnecting adjacent cells. Thirty-six in-out cells are provided which can be customized to output pad drivers or input pad buffers. Inverting or noninverting input pads have protective diodes and resistors. The gate-array is customized by changing only the metal mask.

For the first fabrication, the gate-array has been customized to contain a 31-stage ring oscillator with fan-out of 1, and a 27-stage ring oscillator with fan-out of 3. These will provide data for estimating typical stage delays.

The gate-array by itself is 125 × 125 mils (3.175 × 3.175 mm), and has 40 in-out and power pads. It will mount in a 40-lead chip-carrier package. The circuitry is designed using λ = 2.5 μm design rules. Polysilicon gates are 5 μm (2λ) wide, for instance. Many of the design conventions are based on those used in Mead and Conway,* and by XEROX-PARC for MPC designs.

B. Scaled NMOS

A new NMOS reticle set contains many small test devices and six ring oscillators of various channel lengths. It will be used to develop a short-channel process using thin, thermally grown nitride or oxynitride as the gate dielectric.

C. Laser-Formed Vias

A technique has been developed which uses a laser to form connecting vias selectively between two levels of aluminum wiring on a silicon wafer. The same laser can be used to "zap," or remove, metal thus providing a capability of either adding or deleting connections. These techniques can be used to provide the defect avoidance and user customization for large-area Restructurable VLSI.

Other workers have reported use of a dye laser, multiple pulses, and a post-laser thermal anneal to make connections between metal and silicon through a thin thermal oxide and between metal layers through a deposited oxide. The present work uses a commercial I.C. mask trimmer employing a pulsed laser. Single pulses provide low-resistivity connections with no thermal annealing required. The insulating layer between the two aluminum layers is formed by sputtering 3000 to 6000 A of amorphous silicon.

Chains containing forty 0.25- × 0.25-mil vias between first- and second-level metal were successfully connected with resistances of less than 0.3 ohm per via. Unprogrammed sites exhibit a highly nonlinear resistance, characteristic of the amorphous silicon, with currents in the

*C. Mead and L. Conway, Introduction to VLSI Systems (Addison-Wesley, Reading, Massachusetts, 1980).

nanoamp range at 10 V. Current-carrying capacity in excess of 500 mA was achieved on a number of via chains before blowout.

IV. SILICON PROCESSING

A. Thermal Nitridation

SiO_2 layers 100 to 140 A thick have been converted to a silicon oxynitride by reacting the film with NH_3 and N_2 at approximately 1200 °C. The resulting nitrogen composition of the film is dependent on the initial SiO_2 thickness, the nitridation time, and the nitridation temperature. Breakdown fields of 8 to 12 MV/cm have been achieved with leakage current of $<10^{-8}$ A/cm^2 at 5 MV/cm. The films are resistant to oxidation at 1000 °C in dry O_2 and to etching in buffered HF (7:1). Capacitors fabricated with Al electrodes on a 157-A oxynitride film on silicon were irradiated to 1 Mrad (Si) with 1.5-MeV electrons. Flatband shifts of −0.3 V were observed for capacitors biased at 5 V. This shift is believed to be due to sodium or some other mobile positive-ion contamination in the film.

B. Bipolar Processing

The diagnostic technique of deleting various process steps has identified the epitaxial growth process to be the single most important contributor to bipolar transistor emitter-collector leakage. This result appears valid regardless of whether polysilicon is simultaneously deposited (as in the poly-ox process) or not (as in damaged silicon isolation). Moreover, additional data generated in damaged silicon isolation experiments which use extremely thin epi (<1 μm) indicate that leakage increases with decreasing epitaxial thickness. This condition may be the limiting factor in the damaged silicon isolation technique where the epi thickness needs to be thin enough for neon near-penetration.

A defect decoration etching technique recently described in the literature* has been adopted to investigate backside damage gettering effectiveness. Experiments have verified that the usual methods of backside damage such as ion implantation or mechanical scoring do indeed reduce the etch pit density of the front surface. However, abrading the backsides with a glass-bead blasting apparatus does not reduce the density. Apparently, glass-bead impact does not produce the right kind of crystallographic damage necessary for gettering, as does damage produced by sharp points being scored across the surface.

C. Photosensitive Polyimide

Photosensitive polyimide having exposure times comparable to positive photoresist has been evaluated. It is capable of defining 2-μm features and smaller, seems to produce a uniform surface, and exhibits the high-temperature characteristics expected of polyimide. Work with reactive ion etching of metal-masked polyimide has clearly demonstrated excellent anisotropic etching in material as thick as 30 μm. Slot widths smaller than 0.2 μm have been made in 1.5-μm-thick material, and it appears that depth-to-width ratios of 20:1 or greater are possible.

---

*D.G. Schimmel, "Defect Etch for 100 Silicon Evaluation," J. Electrochem. Soc. 126, 479 (1979).

V. TESTING AND INSTRUMENTATION: MOS CAPACITANCE TEST SYSTEM

As part of a continual upgrading of the TIC MOS capacitor test system, a digital storage oscilloscope has been added to the Zerbst lifetime measurement. This technique uses the measurement of the capacitance of a device which is pulsed into deep depletion and allowed to recover to the inversion state as a basis for the calculation of bulk and surface lifetime values. The previous technique required a series of pulsed measurements in which the capacitance was sampled at successively longer delays. The repeated pulsing of the MOS device tended to modify the charge density and thus compromise the measurement. The use of the digital storage scope allows the storage of a single capacitance-vs-time waveform. This information can be retrieved from the oscilloscope memory by the TIC computer and processed as required to obtain values for the lifetime. Further improvements are expected when a higher-resolution plug-in unit is obtained for the oscilloscope.

COMPUTER SYSTEMS
GROUP 28

The Amdahl 470V/7 central processor, installed toward the end of the previous quarter, is effectively providing Laboratory users with about twice the throughput of the system it replaced. Because of its compatibility, user software has required no changes at all and system software has required only minor changes to reflect physical differences such as configuration and error recording. Tuning of the system for efficient operation has also been related principally to the differences in configuration.

The net result is that the VM time-sharing system on the 470V/7, by both subjective and objective measures, is considerably more responsive and productive. Typical VS batch processing run times have been reduced to half their previous duration.

Notwithstanding this improved performance, average daily central processor use under VM time sharing has steadily moved back up toward the 90-percent level. Furthermore, a full second- and third-shift of batch processing often leaves a backlog of work before switching over to first-shift VM operations. This rapid growth in demand, together with future load projections, has led to the initiation of a study of alternatives for providing computing capacity beyond the planned field upgrade of the 470V/7 to a V/8. It is now likely that the upgrade itself will have to be advanced to FY 81 to handle these growing requirements.

In addition to continuing assignments to provide basic systems services and capabilities, members of Group 28 are involved in broadly based Laboratory efforts aimed at increasing staff productivity through the application of computer technology. One such effort is in the area of publications, which is defined to include various forms of printed text, lecture displays, and simple block drawings.

During this quarter, a Micom word processor has been installed to explore potential benefits of communications between different systems and the capability for producing simple block drawings. In another area, a software working group has been established to investigate and promote the use of modern software engineering techniques for Laboratory programming activities.

SOLID STATE
DIVISION 8

INTRODUCTION

This section of the report summarizes progress during the period 1 May through 31 July 1980. The Solid State Research Report for the same period describes the work of Division 8 in more detail. Funding is primarily provided by the Air Force, with additional support provided by the Army, DARPA, Navy, NASA, NSF, and DOE.

A. L. McWhorter
Head, Division 8

I. Melngailis
Associate Head

DIVISION 8 REPORTS
ON ADVANCED ELECTRONIC TECHNOLOGY

15 May through 15 August 1980

PUBLISHED REPORTS

Journal Articles

JA No.			
4947	Solid Electrolytes Containing Both Mobile and Immobile Alkali Ions	H. Y-P. Hong	J. Power Sources 5, 137 (1980)
5019	Doppler-Limited Spectroscopy of the $3\nu_3$ Band of SF_6	A. S. Pine A. G. Robiette*	J. Mol. Spectrosc. 80, 388 (1980)
5033	The Growth of Large, Laser Quality $Nd_xRE_{1-x}P_5O_{14}$ Crystals	R. D. Plattner* W. W. Kruhler* W. K. Zwicker* T. Kovats* S. R. Chinn	J. Cryst. Growth 49, 274 (1980)
5043	Pump Depletion and Saturation of Two-Photon Resonant Third-Harmonic Generation Processes	H. Kildal S. R. J. Brueck	IEEE J. Quantum Electron. QE-16, 566 (1980)
5049	Deconvolution of Infrared Spectra Beyond the Doppler Limit	J. Pliva* A. S. Pine P. D. Willson*	Appl. Opt. 19, 1833 (1980)
5052	Fabrication and Numerical Simulation of the Permeable Base Transistor	C. O. Bozler G. D. Alley	IEEE Trans. Electron Devices ED-27, 1128 (1980)
5057	Observation of Stimulated Level Shifting in Inverted Atomic Thallium Populations	D. J. Ehrlich R. M. Osgood, Jr. A. Sanchez	Phys. Rev. Lett. 44, 871 (1980)
5065	Ohmic Contact Formation on InP by Pulsed Laser Photochemical Doping	T. F. Deutsch D. J. Ehrlich R. M. Osgood, Jr. Z. L. Liau	Appl. Phys. Lett. 36, 847 (1980)
5067	X-Ray Lithography – A Review and Assessment of Future Applications	H. I. Smith D. C. Flanders	J. Vac. Sci. Technol. 17, 533 (1980)
5068	Direct Writing of Regions of High Doping on Semiconductors by UV-Laser Photodeposition	D. J. Ehrlich R. M. Osgood, Jr. T. F. Deutsch	Appl. Phys. Lett. 36, 916 (1980)
5074	One-Step Repair of Transparent Defects in Hard-Surface Photolithographic Masks via Laser Photodeposition	D. J. Ehrlich R. M. Osgood, Jr. D. J. Silversmith T. F. Deutsch	IEEE Electron. Devices Lett. EDL-1, 101 (1980)

*Author not at Lincoln Laboratory.

JA No.			
5087	Far Infrared Heterodyne Detectors	P. E. Tannenwald	Intl. J. Infrared and Millimeter Waves 1, 159 (1980)
5093	High-Temperature cw Operation of GaInAsP/InP Lasers Emitting at 1.5 μm	J. J. Hsieh	Appl. Phys. Lett. 37, 25 (1980)
5108	High-Speed Operation of $LiNbO_3$ Electro-optic Interferometric Waveguide Modulators	F. J. Leonberger	Opt. Lett. 5, 312 (1980)
5110	Optically Pumped Ce:LaF_3 Laser at 286 nm	D. J. Ehrlich P. F. Moulton R. M. Osgood, Jr.	Opt. Lett. 5, 339 (1980)

Meeting Speeches

MS No.			
5044A	1.0-1.6 μm Sources and Detectors for Fiber Optics Applications	A. G. Foyt	Proc. Intl. Conf. on Lasers '79, Orlando, Florida, 17-21 December 1979, pp. 410-416
5124	Proposed Design of a-Si:H Solar Cells Using Ultrathin Active Layer to Increase Conversion Efficiency	J. C. C. Fan C. O. Bozler	Proc. Fourteenth IEEE Photovoltaic Specialists Conference - 1980, San Diego, California, 7-10 January 1980, pp. 1070-1073
5127	GaAs Shallow-Homojunction Solar Cells	J. C. C. Fan G. W. Turner R. P. Gale C. O. Bozler	Proc. Fourteenth IEEE Photovoltaic Specialists Conference - 1980, San Diego, California, 7-10 January 1980, pp. 1102-1105
5130	A New Technique for Producing Large-Grained Semiconductor Sheets by Laser Crystallization of Amorphous Films	J. C. C. Fan H. J. Zeiger R. P. Gale R. L. Chapman	Proc. Fourteenth IEEE Photovoltaic Specialists Conference - 1980, San Diego, California, 7-10 January 1980, pp. 218-223
5154	Fabrication of Ohmic Contacts on p-Type InP Using Ion Implantation and Laser Annealing	Z. L. Liau N. L. DeMeo J. P. Donnelly D. E. Mull R. Bradbury* J. P. Lorenzo*	In Laser and Electron Beam Processing of Materials, C. W. White and P. S. Peercy, Eds. (Academic Press, New York, 1980), p. 494
5157	Solid-Phase Crystallization Produced by Laser Scanning of Amorphous Ge Films: The Role of Latent Heat in Crystallization Front Dynamics	H. J. Zeiger J. C. C. Fan R. P. Gale R. L. Chapman	In Laser and Electron Beam Processing of Materials, C. W. White and P. S. Peercy, Eds. (Academic Press, New York, 1980), p. 234

*Author not at Lincoln Laboratory.

MS No.			
5169	Redistribution of Implanted Zn in InP After Q-Switched Laser Annealing and the Related Specific Contact Resistance	Z. L. Liau N. L. DeMeo J. P. Donnelly J. C. Norberg* C. G. Hopkins* C. A. Evans, Jr.* J. P. Lorenzo*	In Laser and Electron Beam Processing of Materials, C. W. White and P. S. Peercy, Eds. (Academic Press, New York, 1980), p. 500

* * * * *

UNPUBLISHED REPORTS

Journal Articles

JA No.			
5072	Photo-Acoustic and Photo-Refractive Detection of Small Absorptions in Liquids	S. R. J. Brueck H. Kildal L. J. Belanger	Accepted by Opt. Commun.
5076	Formation of the XeBr Exciplex by Xe-Br_2(D') Collisions	D. J. Ehrlich R. M. Osgood, Jr.	Accepted by J. Chem. Phys.
5083	Laser Micro-Photochemistry for Use in Solid State Electronics	D. J. Ehrlich R. M. Osgood, Jr. T. F. Deutsch	Accepted by IEEE J. Quantum Electron.
5103	Remote Sensing of NO Using a Differential Absorption LIDAR	N. Menyuk D. K. Killinger W. E. DeFeo	Accepted by Appl. Opt.
5111	Infrared Spectroscopy Using Tunable Lasers	H. R. Schlossberg* P. L. Kelley	Accepted as Chapter 4 in Spectrometric Techniques, Vol. 2, G. A. Vanasse, Ed. (Academic Press, New York)
5112	Silicon Graphoepitaxy Using a Strip-Heater Oven	M. W. Geis D. A. Antoniadis D. J. Silversmith R. W. Mountain H. I. Smith	Accepted by Appl. Phys. Lett.
5115	Surface Passivation Techniques for InP and InGaAsP p-n Junction Structures	V. Diadiuk C. A. Armiento S. H. Groves C. E. Hurwitz	Accepted by IEEE Electron. Devices Lett.
5119	The CLEFT Process, A Technique for Producing Epitaxial Films on Reusable Substrates	R. W. McClelland C. O. Bozler J. C. C. Fan	Accepted by Appl. Phys. Lett.
5123	Orientational and Electronic Contributions to the Third-Order Susceptibilities of Cryogenic Liquids	H. Kildal S. R. J. Brueck	Accepted by J. Chem. Phys.

*Author not at Lincoln Laboratory.

JA No.			
5135	High Performance Quasi-Optical GaAs Monolithic Mixer at 110 GHz	B. J. Clifton G. D. Alley R. A. Murphy I. H. Mroczkowski	Accepted by IEEE Trans. Electron Devices

Meeting Speeches*

MS No.			
4530D	High-Resolution Molecular Spectroscopy Using a Tunable Difference-Frequency Laser System	A. S. Pine	High Resolution Infrared Applications and Developments Symp., Gaithersburg, Maryland, 23-25 June 1980
4967B	Graphoepitaxy	D. C. Flanders	Greater New York Chapter American Vacuum Society, RCA Laboratories, Princeton, New Jersey, 4 June 1980
5127A	Recent Advances in High Efficiency, Low Cost GaAs Solar Cells	J. C. C. Fan G. W. Turner R. P. Gale C. O. Bozler	1980 Gordon Research Conference on Crystal Growth, Plymouth, New Hampshire, 14-18 July 1980
5130A	Laser Processing of Semiconductors	J. C. C. Fan H. J. Zeiger R. P. Gale R. L. Chapman	Seminar, Digital Equipment Corporation, Hudson, Massachusetts, 11-12 June 1980
5157A	Solid-Phase Crystallization Produced by Laser Scanning of Amorphous Ge Films: The Role of Latent Heat in Crystallization Front Dynamics	H. J. Zeiger J. C. C. Fan R. P. Gale R. L. Chapman	
5204A	Low Loss GaAs Optical Waveguides Formed by Lateral Epitaxial Growth over Oxide	F. J. Leonberger C. O. Bozler R. W. McClelland I. Melngailis	38th Annual Device Research Conference, Cornell University, Ithaca, New York, 23-25 June 1980
5325	Analog Memory in MNOS Devices: Model and Experiments	R. S. Withers R. W. Ralston E. Stern	
5334	Low Leakage, High Gain GaInAsP/InP Avalanche Photodetectors	V. Diadiuk S. H. Groves C. E. Hurwitz	
5335	Intracavity-Loss-Modulated GaInAsP Diode Lasers	D. Z. Tsang J. N. Walpole S. H. Groves J. J. Hsieh J. P. Donnelly	
5346	Direct Writing of Micrometer-Sized, Highly Doped Regions on Semiconductors by UV-Laser Photodeposition	D. J. Ehrlich R. M. Osgood, Jr. T. F. Deutsch	

*Titles of Meeting Speeches are listed for information only. No copies are available for distribution.

MS No.			
5358	The CLEFT Process: A Technique for Producing Many Single-Crystal Films of GaAs from One Reusable Substrate	R. W. McClelland C. O. Bozler J. C. C. Fan	38th Annual Device Research Conference, Cornell University, Ithaca, New York, 23-25 June 1980
5219A	Integrated Optics and Optoelectronic Switches for Signal Processing	F. J. Leonberger	Workshop on High-Speed Optical and Electronic Devices, Dedham, Massachusetts, 21 June 1980
5232	High-Power Output and Tuning Properties of the UV Solid-State Ce:YLF Laser	D. J. Ehrlich P. F. Moulton R. M. Osgood, Jr.	XI Intl. Quantum Electronics Conference, Boston, 23-26 June 1980
5236	Laser-Induced Photochemical Reactions for Electronic-Device Fabrication	D. J. Ehrlich R. M. Osgood, Jr. T. F. Deutsch	
5237	Recent Advances in Transition-Metal-Doped Lasers	P. F. Moulton A. Mooradian	
5245	Temperature-Dependent Spectral Study of the XeBr Excimer Bands via Two-Photon Optical Pumping	D. J. Ehrlich R. M. Osgood, Jr.	
5373	The ν_3 Multiple-Photon Ladder of SF_6	C. W. Patterson* R. S. McDowell* P. F. Moulton A. Mooradian	
5234	Submicrometer Technology and Devices for VLSI	W. T. Lindley	Electro '80, Boston, 12-15 May 1980
5352	Monolithic Circuit Design	A. Chu	
5236A	Laser-Induced Photochemical Reactions for Electronic-Device Fabrication	D. J. Ehrlich R. M. Osgood, Jr. T. F. Deutsch	Gordon Research Conference, Meriden, New Hampshire, 21-25 June 1980
5243	A Review of X-Ray Lithography	H. I. Smith D. C. Flanders	9th Intl. Conf. on Electron and Ion Beam Science and Technology, St. Louis, Missouri, 11-16 May 1980
5264, 5264B	Recent Advances in Tunable Lasers	A. Mooradian	Intl. Conf. on Lasers, Peking, China, 19-22 May 1980; Seminar, Raytheon Co., Waltham, Massachusetts, 11 June 1980
5264A	Recent Advances in Tunable Lasers	A. Mooradian	Sergio Porto Memorial Conference on Lasers and Applications, Rio de Janeiro, Brazil, 29 June – 3 July 1980
5394	Nonlinear Optics of Cryogenic Liquids	S. R. J. Brueck H. Kildal	

*Author not at Lincoln Laboratory.

MS No.			
5271	Vapor-Phase Epitaxy of InP and GaInAsP	P. Vohl	NATO-sponsored Workshop on InP, Harwichport, Massachusetts, 17-19 June 1980
5285	Synthesis and Crystal Growth of InP	G. W. Iseler	
5324	Liquid-Phase Epitaxial Growth of InP and InGaAsP Alloys	S. H. Groves M. C. Plonko	
5370	The Electro-optic Applications of InP	A. G. Foyt	
5278B	Silicon Graphoepitaxy	M. W. Geis D. C. Flanders D. J. Silversmith D. A. Antoniadis H. I. Smith	Solar Energy Research Institute - Program Review Talk, Washington, DC, 10-12 June 1980
5278C	Graphoepitaxy of Silicon	M. W. Geis	Gordon Research Conference, New London, New Hampshire, 23-25 June 1980
5411	Research at the Limits of Microstructure Fabrication	D. C. Flanders	
5294	Collisional Narrowing of HF Fundamental Band Spectral Lines by Neon and Argon	A. S. Pine	35th Annual Symposium on Molecular Spectroscopy, Ohio State University, Columbus, 16-20 June 1980
5312	Extending the Operating Temperature, Wavelength and Frequency Response of HgCdTe Heterodyne Detectors	D. L. Spears	Intl. Conf. on Heterodyne Systems and Technology, Williamsburg, Virginia, 25-27 March 1980
5320	Surface Dissociation in MBE Growth of GaAs	A. R. Calawa	Electronic Materials Conference, Cornell University, Ithaca, New York, 24-27 June 1980
5321	Phase Diagram for LPE Growth of GaInAsP Layers Lattice-Matched to InP Substrates	J. J. Hsieh	
5322	Properties of W-GaAs Schottky Barriers After High Temperature Anneal	K. B. Nichols C. O. Bozler	
5327	Growth-Temperature Dependence of LPE GaInAsP/InP Lattice Mismatch	Z. L. Liau J. J. Hsieh	
5349	DIAL Measurements of C_2H_4	D. K. Killinger N. Menyuk	Topical Meeting on Coherent Laser Radar for Atmospheric Sensing, Aspen, Colorado, 15-17 July 1980
5385	Surface-Acoustic-Wave Chirp-Fourier-Transform Techniques for Doppler Signal Processing in Laser Radars	R. C. Williamson J. T. Lynch D. R. Arsenault V. S. Dolat	

MS No.			
5369	The Electrical Characteristics of Ion Implanted Compound Semiconductors	J. P. Donnelly	IBMM-80 Conference on Ion Beam Modification of Materials, Albany, New York, 14-18 July 1980
5371	Reactive Ion Etching of Superconducting Devices	S. A. Reible	New England Chapter American Vacuum Society Symp., Danvers, Massachusetts, 17 June 1980
5380	Systems Aspects of SAW Convolvers	J. H. Cafarella	1980 Intl. Microwave Symp., Washington, DC, 28-30 May 1980
5458	Signal Processing with Acoustoelectric SAW Devices	I. Yao	SPIE Annual Intl. Conf., San Diego, California, 29-31 July 1980

SOLID STATE
DIVISION 8

I. SOLID STATE DEVICE RESEARCH

Improved versions of inverted-mesa n^+-InP/n-GaInAsP/n-InP/p^+-InP avalanche photodiode structures have been fabricated and characterized. Uniform avalanche gains of 700, dark current densities of 3×10^{-6} A/cm^2 at a multiplication (M) of 10, and an excess noise factor of 3 (also at M = 10) have been achieved in diodes with wavelength cutoff at 1.25 μm.

A theoretical analysis shows that, under general conditions in broad-area InGaAsP/InP double-heterostructure lasers, an appreciable amount of reabsorption of the spontaneous photons can occur which results in a lowering of the laser threshold current density. Based on these calculations, improved results can be expected if the free-carrier absorption in the InP and the transmission loss through the laser sidewalls are minimized and/or the absorption in the active layer is enhanced.

P-type HgCdTe photoconductors, which can be operated by thermoelectric cooling, have been investigated for use above 77 K as photo-mixers in tactical CO_2-laser systems. The devices (100 μm square) have shown heterodyne sensitivities at 38 MHz of 5×10^{-20} W/Hz at 77 K and 1.8×10^{-19} W/Hz at 195 K, with bandwidths of 140 and 30 MHz, respectively. Bandwidths in excess of 100 MHz at 195 K were achieved with sensitivities of about 4×10^{-19} W/Hz.

II. QUANTUM ELECTRONICS

The first observations of tunable Q-switched operation in Ni:MgF_2 and Co:MgF_2 lasers have been made. In addition, the first mode-locked Ni:MgF_2 laser has been demonstrated and has produced pulses of approximately 100 psec duration.

An analysis of mechanisms giving rise to the nonlinear optical response of semiconductors has been developed. Resonance enhancement effects are identified, and the application to bistability in integrated optical devices is discussed.

A number of modifications made on the quasi-optical radiometer has resulted in an improvement in the system noise temperature to 2900 K. The radiometer was used in the detection of CO in the molecular cloud Orion at 691 GHz, marking the first successful submillimeter heterodyne radio astronomy experiment using an optically pumped far-IR laser local oscillator.

III. MATERIALS RESEARCH

A growth procedure has been developed for using the liquid-encapsulated Czochralski technique to obtain a high yield of InP single crystals capable of providing substrates for research on optoelectronic devices. By establishing a suitable temperature gradient at the growth interface, this procedure minimizes the probability of twinning but does not result in excessive dislocation densities.

In connection with the liquid-phase-epitaxial growth of GaInAsP/InP heterostructures for optoelectronic devices, the phase diagram for growth of GaInAsP layers lattice-matched to (100) and (111)B InP substrates has been established over the temperature range from 570° to 650°C for the entire composition range from InP to the limiting ternary alloy, $Ga_{0.47}In_{0.53}As$. For a given growth temperature and Ga concentration in the liquid phase, the Ga distribution coefficient is always higher for (100) growth than for (111)B growth, but the difference decreases with increasing temperature.

The feasibility of using the trichloride method of vapor-phase-epitaxial growth to obtain GaInAsP/InP heterostructures has been demonstrated by growing lattice-matched GaInAsP layers on (100) InP substrates. Further development of this method, which uses PCl_3 and $AsCl_3$ as the sources of the Group V elements, would be required to achieve the degree of alloy composition control desired for device applications.

Heteroepitaxial $Ge_{1-x}Si_x$ alloy films of good crystal quality have been obtained by transient heating of Ge-coated Si single-crystal samples with a graphite strip-heater. On the basis of initial experiments on the chemical vapor deposition of GaAs layers on these alloy films, there appear to be no serious obstacles to the fabrication of high-efficiency, low-cost GaAs solar cells utilizing the GaAs/$Ge_{1-x}Si_x$/Si structure.

Liquidus isotherms for temperatures from 425° to 600°C and solidus lines for CdTe mole fractions between 0 and 0.7 have been determined for the Te-rich corner of the Hg-Cd-Te system. From the data, it is clear that a very wide range of $Hg_{1-x}Cd_xTe$ compositions can be grown at temperatures of 425° to 600°C by liquid-phase-epitaxial techniques.

IV. MICROELECTRONICS

A simple technique has been developed for exposing large-area, low-distortion, periodic structures. The technique, called spatial-period-division, employs near-field diffraction from periodic and quasi-periodic parent masks to produce intensity patterns with spatial periods finer than the parent mask. Spatial-period-division used in conjunction with soft x-ray lithography should be especially attractive for exposing structures with periods below 100 nm.

Two schemes have been implemented for fixed-pattern-noise cancellation in a SAW/CCD time-integrating correlator. One method uses a second CCD chip to store the fixed-pattern noise for subsequent subtraction from the SAW/CCD output, and the other uses an A/D converter and a computer for digital post-processing of the correlator output. The dynamic range of the device has been improved to 40 dB from 20 dB.

A GaAs integrated mixer consisting of a slot coupler, a coplanar transmission line, a surface-oriented Schottky-barrier diode, and an RF bypass capacitor all monolithically integrated on the GaAs surface has been fabricated for operation at 110 GHz. The monolithic mixer module mounted in the end of a waveguide horn has an uncooled double-sideband mixer noise temperature of 339 K and a conversion loss of 3.8 dB.

Lateral overgrowth of single-crystal Si over an SiO_2 bar structure on a single-crystal silicon substrate has been achieved by epitaxial growth using the reduction of silane in a hydrogen gas environment. Up to 4 μm of lateral overgrowth has been observed for thin (≤0.03 μm) SiO_2 bars on (100)-oriented silicon wafers. The amount of overgrowth is dependent on the orientation of the silicon substrate and the thickness of the SiO_2 layer.

V. ANALOG DEVICE TECHNOLOGY

A theoretical model has been developed which explains an earlier experimental demonstration of analog nonvolatile memory in metal-nitride-oxide-semiconductor (MNOS) capacitors. Experiments have successfully extended such analog memory behavior to devices produced by a process compatible with charge-coupled-device (CCD) technology. These results indicate the feasibility of an integrated MNOS/CCD analog memory, and work to fabricate such a memory is now under way.

$LiNbO_3$ surface-acoustic-wave edge-bonded transducers have been fabricated on ST quartz and ⟨001⟩-cut GaAs substrates. Efficient transduction has been demonstrated in the vicinity of 100 MHz with fractional bandwidths of 50 and 91 percent for the quartz and GaAs substrates, respectively. Conversion loss as low as 4 dB has been measured for quartz. A model which accurately predicts this transducer performance has been devised.

Recent experiments have demonstrated the feasibility of using an acoustoelectric coherent integrator for programmable processing of burst waveforms of the type employed in Doppler radar systems. The device output, as a function of Doppler-shifted input, produced the expected Doppler ambiguity functions for 3-μsec gated-CW subpulses in bursts of 2, 4, 8, 16, and 32 subpulses.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ESD-TR-80-95	2. GOVT ACCESSION NO. AD-A092 704	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Advanced Electronic Technology		5. TYPE OF REPORT & PERIOD COVERED Quarterly Technical Summary 1 May - 31 July 1980
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Alan J. McLaughlin and Alan L. McWhorter		8. CONTRACT OR GRANT NUMBER(s) F19628-80-C-0002
9. PERFORMING ORGANIZATION NAME AND ADDRESS Lincoln Laboratory, M.I.T. P.O. Box 73 Lexington, MA 02173		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Program Element No. 63250F Project No. 649L
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Systems Command, USAF Andrews AFB Washington, DC 20331		12. REPORT DATE 15 August 1980 13. NUMBER OF PAGES 28
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Electronic Systems Division Hanscom AFB Bedford, MA 01731		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

None

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

digital computers	Lincoln Terminal System	laser research
integrated circuitry	computer systems	quantum electronics
magnetic films	solid state devices	microelectronics
education technology	materials research	analog device technology

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This Quarterly Technical Summary covers the period 1 May through 31 July 1980. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)